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Use of co-verbal gestures during word-finding difficulty among Cantonese speakers with fluent aphasia and unimpaired controls

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Abstract

Background—Co-verbal gestures refer to hand or arm movements made during speaking. Spoken language and gestures have been shown to be tightly integrated in human communication.

Aims—The present study investigated whether co-verbal gesture use was associated with lexical retrieval in connected speech in unimpaired speakers and persons with aphasia (PWA).

Methods & Procedures—Narrative samples of 58 fluent PWA and 58 control speakers were extracted from Cantonese AphasiaBank. Based on the indicators of word-finding difficulty (WFD) in connected speech adapted from previous research, and a gesture annotation system with independent coding of gesture forms and functions, all WFD instances were identified. The presence and type of gestures accompanying each incident of WFD were then annotated. Finally, whether the use of gesture was accompanied by resolution of WFD, i.e., the corresponding target word could be retrieved, was examined.

Outcomes & Results—Employment of co-verbal gesture did not seem to be related to the success of word retrieval. PWA's naming ability at single-word level and their overall language ability (as reflected by the aphasia quotient of the Cantonese version of the Western Aphasia Battery) were found to be the two strongest predictors of success rate of resolving WFD.

Conclusions—The Lexical Retrieval Hypothesis highlighting the facilitative functions of iconic and metaphoric gestures in lexical retrieval was not supported. Challenges in conducting research related to WFD, and the clinical implications in gesture-based language intervention for PWA were discussed.

Keywords

co-verbal gestures; aphasia; discourse; lexical retrieval; word-finding difficulty; Cantonese

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Declaration of interest
The authors report no conflicts of interest and are responsible for the content of the paper.

Introduction

Spoken language and gestures are tightly integrated in human communication (Göksun, Lehet, Malykhina, & Chatterjee, 2015). Co-verbal gestures refer to hand or arm movements made during speaking (Willems & Hagoort, 2007). They are a form of non-verbal means of communication commonly found in everyday interaction. It has been proposed that language parallels gesture use in humans and both modalities of expression originate from the same system (e.g., Butterworth & Hadar, 1989; McNeill, 1992, 2005) and, therefore, are subject to impairment at the same time. An opposite view, where language and gestures are from separate but interrelated systems, has also been put forth. This position emphasized that language and gestures are complementary to each other, i.e., gestures may play a facilitative role to compensate for one's language impairment. For example, the Information-packaging Hypothesis (Kita, 2000) specifies that the role of gestures is to help organize and package information as an integral part of the whole process of language formulation. Other similar models include the Mutually Adaptive Modalities Hypothesis (de Ruiter, 2006), Trade Off hypothesis (de Ruiter, Bangerter, & Dings, 2012; Van der Sluis & Krahmer, 2007), and Lexical Retrieval Hypothesis (Krauss, Chen, & Gottesman, 2000), which highlight the functional role of lexical gestures, particularly iconic and metaphoric gestures (McNeill, 1992), in word finding.

Persons with aphasia (PWA) often experience the clinical feature of anomia, or word-finding difficulties (WFD), which impact their daily communication. The Lexical Retrieval Hypothesis has been utilized as the basis of word finding training, assuming that gesture employment may improve PWA's naming ability at the lexical level (see Rose, Raymer, Lanyon, & Attard, 2013). WFD in connected speech have also been reported, together with a range of indicators suggested for identifying incidents of anomia. They include verbal, phonemic, or semantic paraphasias, neologism/jargon, false-start, revision or reformulation, repetition, pause and/or filler greater than two seconds, abandoned sentence, deletion, personal comment indicating difficulty in retrieving targets, indefinite words, overuse of pronoun or pronoun without antecedents, and circumlocution. Details of these indicators can be found in Boyle (2014, 2015), Brookshire and Nicholas (1995), Doyle et al. (2000), and McNeil et al. (2007).

Evidence supporting Lexical Retrieval Hypothesis

Studies investigating the role of co-verbal gestures for lexical retrieval have adopted different approaches and designs. One of the approaches is to examine the effects of restricting gesture use on speech fluency in unimpaired speakers. For example, Graham and Heywood (1975) compared unimpaired speakers' (n=6) description of geometrical line drawings in free versus restricted gesturing conditions. The group with restricted gesture use was characterized by altered semantic content of utterances and increased pausing time. Morsella and Krauss (2004) also examined how unimpaired English speakers (n=79) utilized gestures when asked to describe visual objects that were either present or absent in front of them. Speakers with restricted gesturing were found to have more dysfluent speech output. Similar conclusions have been drawn by Rauscher, Krauss, and Chen (1996) who studied the description of animated cartoons in 41 unimpaired speakers. Participants restricted from gesturing were observed to be less fluent and used more filled pauses in their output involving spatial content. Such a difference was absent in output containing non-spatial contents. Another approach examined the effects of restricting gesture use among unimpaired speakers during moments of tip-of-the-tongue (TOT), which could typically be induced by oral naming tasks upon presentation of definitions of low-frequency words. A facilitative effect of gesture was illustrated by Frick-Horbury and Gutentag (1998) who observed significantly more words retrieved by participants who were allowed to gesture (than those who were restricted). In short, the above studies supported the Lexical Retrieval Hypothesis as they showed the effects of restricting gesturing use on spoken output, resembling occurrence of WFD. Recently, de Ruiter (2006) has further interpreted the results of the above studies and claimed that gestures compensated for, instead of assisted, lexical retrieval. It was argued that as spatial terms were more efficiently expressed through gestures, the language modality had to be adapted to be more elaborate. Thus, the reduction of speech fluency with spatial terms upon restriction of gesture was not unexpected.

Another source of evidence supporting the Lexical Retrieval Hypothesis came from studies of PWA. The systematic review on gesture treatments for post-stroke aphasia (Rose et al., 2013) highlighted the clinical importance of introducing symbolic gestures to improve PWA's picture naming (in group or single-case experiments). Iconic gestures have been claimed to facilitate object naming in PWA impaired in phonological access, storage, or encoding (Rose & Douglas, 2001). Gesture interventions for anomia might be combined with verbal elements, both of which had been shown to alleviate WFD in confrontation naming (e.g., Raymer et al., 2006; Rose & Sussmilch, 2008)[1]. When gestures accompanying conversations with or without WFD were examined in PWA (n=18), Lanyon and Rose (2009) observed that participants resolved more WFD through meaning-laden gestures; that was not the case without gestures. Hence, use of gestures seemed to benefit English-speaking PWA's word retrieval in both single word and connected speech production.

Recently, two large-scale studies comparing Cantonese-speaking PWA and controls have suggested PWA's gesture use play a critical role in facilitating word finding. Using transcripts and videos retrieved from Cantonese AphasiaBank[2] (Kong & Law, 2015), Kong, Law, Wat, and Lai (2015) examined the use of co-verbal gestures in spoken discourses (a monologue, two stories, and a procedural description) produced by 131 PWA and 48 controls. Gestures annotation followed procedures and guidelines in Kong, Law, Kwan, Lai, and Lam (2015). There was a total of six gesture forms: iconic, metaphoric, deictic, emblem, beat, and non-identifiable, and eight gesture functions: (i) providing substantive information, (ii) enhancing speech content, (iii) providing alternative communication means, (iv) guiding and controlling speech flow, (v) reinforcing intonation or speech prosody, (vi) assisting lexical retrieval, (vii) assisting sentence re-construction, and (viii) no specific functions deduced. It was observed that higher use of gestures in the PWA group was associated with improved lexical retrieval. A follow-up study by Kong, Law, and Chak (2017) compared co-

[1]The degree of treatment effects might depend on whether a PWA's WFD is phonologically or semantically based (e.g., Rose & Sussmilch, 2008).
[2]For details of the database (e.g., participant characteristics, language and video sample setup, or behavioral and/or language test results), refer to Kong et al. (2017).

verbal gesture employment among 23 fluent PWA, 21 non-fluent PWA, and 23 controls. The results revealed an association between improved WFD and use of non-content-carrying gestures among PWA (unlike the use of content-carrying gestures in controls during WFD). As these two studies adopted an observational design to examine the co-occurrence of gesture and resolution of word retrieval, a causal relationship between the two could not be established. Moreover, the demonstration of a clear connection between the gestures employed and their corresponding function(s) was potentially limited by the methodology adopted in Kong, Law, Wat, et al. (2015) and Kong et al. (2017). Specifically, all instances of gestures were first identified, and the form and primary function of the identified gestures were subsequently coded based on the corresponding content of production. As such, it was not possible to disentangle if a gesture was necessarily produced during lexical retrieval problems, or for other communicative purposes (or for both of them). Critically, WFDs not accompanied by gestures were not identified.

Aims

To examine the relationship between co-verbal gesture use and lexical retrieval more rigorously among unimpaired speakers and PWA, the current study adopted a method different from Kong, Law, Wat, et al. (2015) and Kong et al. (2017). All instances of WFD in controls and PWA were first identified, before examining if each incident co-occurred with the speakers' employment of a gesture. Subsequently, whether the target was successfully retrieved after using the gesture would be determined. This investigative approach, similar to Lanyon and Rose (2009), should reveal a more complete picture of the relationship between WFD and gesture employment. Specifically, this study aimed to address these research questions:

(RQ1) When unimpaired speakers and PWA experienced WFD, how frequently did they employ co-verbal gestures? Among instances of gesture use, did the two groups use gesture forms differently, based on the six gesture forms in Kong, Law, Kwan, et al. (2015)?

(RQ2) Was employment of co-verbal gestures after WFD associated with improved retrieval of target lexicons? And did unimpaired speakers and PWA show different patterns (and distribution) of gesture forms?

(RQ3a) How well did speaker group and gesture use predict success rate of target word retrieval?

(RQ3b) For PWAs, how predictive were factors of gesture use, aphasia severity, semantic processing integrity, and naming ability of success rate of resolving WFD?

Methods

Participants

A total of 116 participants were selected from Cantonese AphasiaBank. They included 58 fluent PWA and 58 controls matched in age (±3 years) and education (±3 years). Each participant group aged between 30 and 75 years (PWA: mean = 55.42, SD = 9.21; Controls: mean = 55.20, SD = 9.54), and the range of education level was 0-16 years in the PWA (mean = 9.31, SD = 3.38) and 3-16 years in the control group (mean = 10.19, SD = 2.86). According to the CAB, there were 55 PWA with anomic and three with transcortical sensory aphasia (mean aphasia quotient; AQ = 88.83, SD = 6.52). This study focused on fluent PWA as they were expected to produce narratives with WFD that could be easily identified. This is unlike non-fluent PWA who would very often struggle with WFD and sentence construction at the same time.

Data

For each participant, three narrative samples were extracted from the database, including procedural description of making an egg and ham sandwich, and story-telling of "The Boy Who Cried Wolf" (Story 1) and "The Hare and the Tortoise" (Story 2). These samples were reviewed to see if any speakers had shown obvious confusion about the content or if the picture cue was accidentally present during story-telling production; such data were excluded from analysis. After this step, a total of 58 procedural samples, 51 samples of Story 1, and 55 samples of Story 2 in the PWA group were processed. As for the control group, there were 58 procedural samples, 54 samples of Story 1, and 57 samples of Story 2.

Data analysis

For each video, all incidents of WFD were identified using the indicators previously reviewed in Introduction. Details about the definitions, source, and examples of each indicator are given in Appendix A. Note that an instance of WFD may be reflected by one or more WFD indicators. Data analysis was conducted in ELAN (Max Planck Institute for Psycholinguistics, 2002). Three independent tiers, namely "WFD (success)", "WFD_signs" and "WFD_gestures", were created for each file (see Figure 1).

All WFD indicators shown in each occurrence of WFD were annotated in the tier "WFD_signs". After the identification stage, the success of word-retrieval in each WFD instance was determined based on whether the production matched the expected target words in the task. The success of word retrieval was annotated in the tier "WFD (success)" with an annotation of 'Y' or 'N' representing successful or unsuccessful resolutions. For each WFD, all gestures produced within the time window of the WFD instance were also noted[3]. The corresponding gesture form(s) (Kong, Law, Kwan, et al., 2015) of the identified gestures were recorded in the tier "WFD_gestures".

Inter- and Intra-rater reliability

Data from six PWA and six controls (10% of total samples) were randomly selected. This subset of data was reanalyzed by an independent rater and also by the third author to establish the inter-rater and intra-rater reliabilities, respectively. The independent rater received a 3-hour training on the gesture annotation system, with examples of annotated videos and hands-on practice on annotating WFD, prior to coding. Kendall's tau coefficients and point-to-point agreement were employed to examine the consistency of coding the WFD indicators, gesture forms, and incidents of successful WFD. As shown in Table 1, all Kendall's tau coefficients were statistically significant, suggesting a high consistency

[3]The number of gestures might vary from zero to the number of gestures identified.

between raters in the identification of WFD indicators, assignment of gesture forms, and determination of successful target word retrieval. The coefficients of intra-rater reliability were generally higher than those of inter-rater reliability; this was also the case for point-to-point agreements[4].

Statistical analysis

RQ1 was addressed by examining descriptive statistics. Prior to addressing RQ2, a subset of the participants (24 control-PWA pairs) who had used gestures at least once during WFD were selected. A two-way mixed ANOVA was conducted with the within-subject factor of two levels (with gestures and without gestures), and the between-subject factor (control and PWA). The dependent variable was the success rate of word retrieval during WFD. There were two success rates calculated for each participant: (i) success rate with the use of gestures (i.e., percentage of the total number of successful resolution of WFD with presence of gestures ÷ total number of WFD with presence of gestures), and (ii) success rate without the use of gestures (i.e., percentage of the total number of successful resolution of WFD without gestures ÷ total number of WFD without gestures).

Two stepwise multiple regression analyses were conducted to answer RQ3a and RQ3b, respectively. Prior to that, the overall success rate of word retrieval (i.e., percentage of the total number of successful resolution of WFD ÷ total number of WFD) was calculated for each participant. In addition, the ratio of content-carrying to non-content carrying gesture (i.e., total number of iconic, metaphoric, deictic, and emblem gestures ÷ total number of beat and non-identifiable gestures) was computed. This ratio was chosen to be the predictor of gesture use in this study because Kong, Law, and Chak (2017), who examined gesture employment in Cantonese-speaking controls and PWA, revealed a double dissociation of content-carrying versus non-content carrying gestures for facilitating lexical retrieval in the two speaker groups.

To address RQ3a, the predicted variable (i.e., success rate of word retrieval) of all participants and the following predictor variables were entered to generate a correlation matrix: (1) speaker group, and (2) ratio of content-carrying to non-content carrying gesture. Similarly, to address RQ3b, the same predicted variable and the predictor variables of PWA's language test scores (extracted from Cantonese AphasiaBank) were employed to generate a correlation matrix: (1) CAB AQ representing aphasia severity, (2) scores of Spoken Word-Picture Matching (SWPM), (3) scores of Written Word-Picture Matching (WWPM), (4) adopted Pyramid and Palm Tree Test (PPTT) scores, (5) scores of Synonym Judgment Test, (6) scores of selected items PPTT and Associative Match test in the Birmingham Object Recognition Battery representing non-verbal semantics abilities, (7) object naming scores, (8) action naming scores showing oral naming ability, and (9) ratio of content-carrying to non-content carrying gesture. Only those variables, except for gesture use, with significant correlation coefficient with success rate were chosen for conducting a stepwise multiple regression analysis. Furthermore, when two predictor variables were statistically highly correlated with each other, the one showing a higher correlation, i.e.,

[4]A careful post-hoc examination of the raw data revealed that disagreements on WFD identification between raters mainly occurred in ungrammatical, slurred, or poorly articulated utterances.

higher criterion coefficient, with the success rate was entered in the regression analysis to avoid multicollinearity.

Results

There were 1,162 and 1,779 incidents of WFD in the control and PWA group, respectively. All participants experienced WFD at least once in their production tasks. The distribution of WFD indicators across the two groups is shown in Table 2. The top three WFD indicators for both speaker groups were false-start, revision, and repetition. Table 3 details the participants' use of different gestures in connection to different indicators of WFD. PWA tended to employ non-identifiable gestures after WFD indicated by false-starts and repetitions. The controls also used the same types of gestures after WFD indicated by false-starts and revisions.

Concerning RQ1, a total of 14 PWA and 34 control speakers did not employ any gestures during WFD. The mean rate of gesture was 33.4% in PWAs (SD = 33.6%, 0-100%), but only 9.4% in controls (SD = 15.8%, 0-59%). Interesting, gestures were not necessarily employed during WFD. Our findings suggested that, for both speaker groups, over half of the identified WFD were not followed by the use of gestures. On average, the PWA employed gestures in 40.0% of their WFD (n=1,308), which was more than four times the rate of the controls (9.4% of WFD; n=989).

When controls and PWA experienced WFD and employed co-verbal gestures, both groups used non-identifiable gestures most frequently, followed by deictic gestures (RQ1). This observed distribution of gesture forms did not seem to be related to whether the WFD was eventually resolved, i.e., the corresponding target words were successfully retrieved, or not (RQ2). Table 4 displays the distribution of gestures forms during WFD of our participants.

As to whether employing co-verbal gestures was associated with greater success of target word retrieval when PWA (and control speakers) experienced WFD (RQ2), the results of the two-way mixed ANOVA revealed a significant main effect of speaker group (i.e., the between-subject factor) [$F(1, 46) = 6.45$, $p < .05$, $\eta^2 = .12$]. The success rate of target word retrieval was significantly higher for control speakers (mean = 78.6%, SD = 3.9%) than the PWA (mean = 64.7%, SD = 3.9%). However, neither the main effect of gesture use nor the interaction effect was significant ($p > .65$), indicating that gesture use did not affect success rate of word retrieval in either speaker group.

Addressing RQ3a, the results of the stepwise multiple regression analysis suggested that only "speaker group" significantly predicted success rate ($\beta = 0.328$, $p < .01$); it accounted for 10.8% of the variance of the success rate [$F(1, 58) = 7.004$, $p < .01$; $R^2 = .108$]. In regard to the best predictor for success rate of target word retrieval in PWA (RQ3b), descriptive statistics of the predicted variable (i.e., success rate of word retrieval) and the predictor variables are given in Table 5. A correlation matrix between predicted and predictor variables is shown in Table 6. Success rate was significantly correlated with CAB AQ, SWPM, object naming and action naming scores. Among the predictors, oral naming and action naming scores were conceptually and statistically highly correlated as they both assessed naming abilities. Since the correlation coefficient of object naming was greater than that of action naming, object naming was selected as the predictor variable. The predictor variables finally included in the stepwise regression were (1) CAB AQ, (2) SWPM score, (3) object naming score, and (4) ratio of content-carrying to non-content carrying gestures. The predictor variables that significantly predicted success rate were object naming and CAB AQ. Object naming accounted for 35.9% of the variance, and CAB AQ accounted for an additional 8.8% (see details in Table 7).

Discussion

The present investigation examined whether and how co-verbal gestures were associated with lexical retrieval in connected speech among fluent PWA and controls. It distinguished from most previous examinations in terms of a much bigger sample size of PWA with carefully matched control speakers. One may consider it a response to Cocks, Dipper, Middleton, and Morgan (2011) who have emphasized the critical need of larger-scale studies exploring gestures in PWA.

Somewhat contrary to common expectation, unimpaired speakers appeared to have experienced many WFD, on average 20.03 WFD per control (versus 30.67 per PWA). We attribute the unexpected observation to our application of a comprehensive (and thus larger) set of 15 WFD indicators to unimpaired speakers whose WFDs have rarely been systematically examined. Out of the nine original investigations from which we adapted the indicators, only two included unimpaired participants (i.e., Brookshire & Nicolas, 1995; Schmitter-Edgecombe et al., 2000). Our findings, therefore, constitute important empirical evidence of the WFD phenomenon in spontaneous spoken narratives of unimpaired individuals, challenging the typical assumption of minimal or lack of WFD drawn from studies of single-word production.

Our analyses also found that over half of the controls and around 25% of the PWAs did not employ any gestures when experiencing WFD, compatible with Rauscher et al.'s (1996) hypothesis that gesture employment was dependent on whether the speech content involved spatial references, and the fact that the discourse tasks in this study (i.e., procedural description and story-telling) did not require much description of visuo-spatial information. To better verify Rauscher et al.'s claim, future studies may use discourse tasks that involve topics or contents with spatial references, to create a greater demand for participants to gesture. Moreover, there were qualitative differences between the WFD indicators shown in PWA and control groups. Revision was the second and third most frequent sign of WFD in controls and PWA, respectively; pauses and fillers were also frequent in PWA but not in controls. Note that the indicators of pauses, fillers, and revisions may have been caused by factors other than WFD, as they are commonly associated with planning, formation, or organizing a clause or a sentence, or reorganizing or reformulating ideas during spoken discourse production (Blankenship & Kay, 1964; Clark, 2002; Maclay & Osgood, 1959). Differentiating the underlying causes of occurrence of these signs may be crucial to understanding their corresponding connection to various communication breakdown of discourse.

The Lexical Retrieval Hypothesis specifies that only lexical gestures, particularly iconic and metaphoric, can facilitate word retrieval because of their embedded motoric information of the concepts of lexicons. However, most previous studies involving PWA (such as Lanyon & Rose, 2009) are limited in terms of their lack of full-scale considerations of different non-content-carrying gestures. The absence of main effect of gesture use in our findings does not support the Lexical Retrieval Hypothesis. The observed high proportions of non-identifiable form of gestures in both PWA and controls (as compared to around 10% of iconic and metaphoric forms) associated with WFD are also worth noting. In fact, Kim, Stierwalt, LaPointe, and Bourgeois (2015) reported results comparable to ours in which co-verbal movements (similar to non-content carrying gestures) outnumbered iconic and deictic gestures used by PWA during WFD. These findings have collectively contradicted Lanyon and Rose (2009), in which meaning-laden gestures accounted for more than 90% of all gestures produced during WFD in conversational samples of PWA.

Note that when our unimpaired speakers and PWA were successful in retrieving target words using gestures, the distribution of gesture forms was similar to that of all incidents of WFD (irrespective of resolution of WFD). This is consistent with Beattie and Coughlan (1999) and Cocks, Dipper, Pritchard, and Morgan (2013), in which no particular gesture form was related to resolving WFD in connected speech. Interestingly, it was the controls (not PWA) who were more successful in resolving WFD in spoken discourse with the use of gestures.

Regarding factors that were predictive of success rate of resolving WFD in discourse, it was found that PWA’s object naming score was the strongest predictor, followed by CAB AQ. This finding parallels the strong and positive correlation between picture naming and noun or content word production in conversation reported by Herbert, Hickin, Howard, Osborne, and Best (2008). It further supports that the mental processes involved in lexical retrieval during picture naming and production of connected speech are similar. PWA with a higher CAB AQ are less impaired in overall language skills and, thus, more capable of resolving WFD. The above observations are clinically important in two ways. Firstly, rehabilitation of anomia at the single-word level may potentially enhance naming at the discourse level. Secondly, one may expect better prognosis in PWA’s word retrieval in spoken discourse for those with better confrontation naming performance; this is especially the case for those who demonstrate a higher overall degree of language integrity.

In an attempt to determine the communicative functions of the iconic and metaphoric gestures produced by our participants during WFD, we cross-checked the independent annotations of gesture forms and functions in our previous studies (Kong, Law, Wat, et al., 2015; Kong et al., 2017). It was found that these gestures were coded for function of enhancing language content or providing additional information to listeners. Following Holler, Turner, and Varcianna (2013) who concluded that representational gestures (similar to our iconic and metaphoric gestures) were produced for communicative purposes during TOT in unimpaired speakers, it is argued that iconic and metaphoric gestures serve another important (and additional) clinical function that may be incorporated into rehabilitation aiming at PWA’s communication. Since the current study has focused on PWA with fluent aphasia, examining whether and how our findings may be applicable to a wider range of aphasia syndromes and severity is recommended.

Distinction between errors of word production (e.g., resulting from phonetic encoding errors or apraxia of speech) and word retrieval (e.g., resulting from degraded semantics, poor semantic to phonologic mapping, or poor phonologic access/encoding) is not straightforward. It was possible that the WFDs coded in the present investigation, in fact, included word production errors, given the relatively broad definitions and features of WFDs. The mechanisms for gestures to potentially facilitate word retrieval errors are more clearly understood than those for word production errors (Lanyon & Rose, 2009); this was also highlighted in a recent experimental study by Kroenke, Kraft, Regenbrecht, and Obrig (2013) who reported gesture facilitation effects for PWA with phonological access problems (but not for those with purely semantic or word production problems). Due to the inclusive coding approach adopted here, one may argue the possible masking effect of particular gesture types on specific WFDs, which can be considered as a limitation of this study.

Previous research on PWA's use of gesture has suggested a close relationship between gesture and the semantics of language based on English speakers (e.g., Kita & Ozyurek, 2003; Cocks et al., 2013; Dipper, Pritchard, Morgan, & Cocks, 2015) and Cantonese-speaking PWA (see Kong, Law, Wat, et al., 2015). In light of the comprehensiveness of our existing coding system of WFD, as shown in Table 3, two indicators including "comment" and "circumlocution" were noted to be rarely present in the raw data. Interestingly, some of our Cantonese-speaking participants showed some unique patterns of WFD that did not fall into the existing framework of WFD indicators. They include prolonging a word preceding the target word, and replacing the target word with a relevant English word, among others. Given that speakers of different languages are characterized by their use of culturally unique gestures (Graham & Argyle, 1975; Kendon, 1997; Yammiyavar, Clemmensen, & Kumar, 2008), these signs may be cultural-specific. Future examination involving more systematic investigations in how linguistic properties of Chinese may affect gesture use in typical speakers and those with aphasia is warranted.

Appendix A

Description of WFD Indicators

Sign	Definition	Example	Sources
Verbal paraphasia	Substitution of the target word by a semantically-related or unrelated real word	Production in TorHa PAR: 兔 就 同 貓 賽跑. %mor: n|tou3=rabbit adv|zau6=then prep|tung4=with n|maau1=cat v|+v|coi3+v|paau2=race. gloss: The rabbit then races with the cat. [In this example, the target word 'wolf'(狼) was substituted by 'cat'(貓).]	Boyle, 2004, 2014; Pashek & Tompkins, 2002; Schmitter-Edgecombe, Vesneski, & Jones, 2000
Phonemic paraphasia	Substitution of the target word by a non-word which is phonologically-related to the target word	Production in CryWf PAR: 突然間 就 嗌 狼 liu4 [: 來] 了. %mor: adv|dat6jin4gaan1=suddenly adv|zau6=then v|ngaai3=shout n|long4=wolf v|loi4=come sfp|liu5.	Boyle, 2004, 2014, 2015; Mayer & Murray, 2003

Sign	Definition	Example	Sources
		gloss: Then, (he) suddenly shouts ‘Here (comes) the wolf’. [In this example, the target word ‘come’ (來), which should be pronounced as ‘loi4’ in Cantonese, was realized as ‘liu4’.]	
Neologism/jargon	Substitution of the target word by non-words which are phonologically unrelated to the target word	Production in EggHm PAR: 啲 &jau4jau4zau2zau4 切 咗 啲 邊. %mor: cl|di1=some v|cit3=cut asp|zo2=perfective cl|di1=some n|bin1=side. gloss: Cut the sides of the (bread). [In this example, the target word ‘bread’(麵包), which should be pronounced as ‘min6baau1’ in Cantonese, was realized as ‘&jau4jau4zau2zau4’.]	Boyle, 2004, 2014; Brookshire & Nicholas, 1995; Pashek & Tompkins, 2002
False-start	Partial production of the target word or its substitution; a phonological fragment	PAR: 佢 嘅 工作 呢. 就係 &f &f 負責 放羊 啦. %mor: pro|keoi5=he poss|ge3=possessive n|gung1zok3=work sfp|ne1. adv|zau6hai6=that_is v|+v|fu6+n|zaak3=be_responsible_for v|+v|fong3+n|joeng4=herding_sheep sfp|laa1=imperative. gloss: In his work, he f… f… is responsible for herding the sheep. [In this example, before producing the target word ‘be responsible for’ (負責), phonological fragment ‘&f&f’ was produced.]	Boyle, 2004, 2014, 2015; Brookshire & Nicholas, 1995; Doyle et al., 2010; McNeil et al., 2007
Revision	Changes or reformulations made to one or more previous words	PAR: 嗰 隻 貓 即係 嗰 隻 龜 爬 囉. %mor: dem|go2=that cl|zek3=cl n|maau1=cat adv|zik1hai6=that_is dem|go2=that cl|zek3=cl n|gwai1=tortoise v|paa4=crawl sfp|lo1 gloss: The cat, I mean the tortoise, crawls.	Boyle, 2004, 2014; Doyle et al., 2010; Mayer & Murray, 2003; McNeil et al., 2007; Schmitter-Edgecombe et al., 2000
Repetition	Exact repetition of words or phrases that are not produced for emphasis	PAR: 就 冇 去 [/] 去 [/] 去 救 佢 嘞. %mor: adv|zau6=then adv:neg|mou5=no v|heoi3=go v|gau3=rescue pro|keoi5=he sfp|laak3. gloss: Then, (they) do not go… go… go… (to somewhere and) save him.	Boyle, 2004, 2014, 2015; Brookshire & Nicholas, 1995; Doyle et al., 2010; McNeil et al., 2007; Schmitter-Edgecombe et al., 2000
Pause	A within-utterance prolonged unfilled pause which lasts for at least two seconds	PAR: 到 最後 呢 就係 (..) 龜 係 贏 咗 嘞. %mor: v|dou3=arrive adv|zeoi3hau6=lastly sfp|ne1 adv|zau6hai6=that_is n|gwai1=tortoise v|hai6=be v|jeng4=win asp|zo2=perfective sfp|laak3. gloss: At last, it is (pause) the tortoise that has won.	Doyle et al., 2010; Mayer & Murray, 2003; Pashek & Tompkins, 2002

Sign	Definition	Example	Sources
Filler	A within-utterance prolonged filled pause which lasts for at least two seconds	PAR: 跟住 可以 用 e6 e6 e6 嗰 啲 刀 啦. %mor: adv|gan1zyu6=then aux|ho2ji5=may v|jung6=use fil|e6 fil|e6 fil|e6 dem|go2=that cl|di1=some n|dou1=knife sfp|laa1=imperative. gloss: Then, (we) can use (fillers) those knives.	Mayer & Murray, 2003; Pashek & Tompkins, 2002
Abandoned sentence	An utterance which is voluntarily stopped by the speaker before it is completed	PAR: 而 小白兔 因爲 瞓著 咗. 所以 就 冇 +… %mor: conn|ji4=and n|siu2baak6to3=rabbit conn|jan1wai6=because v|+v|fan3+adj|zoek6=fall_asleep asp|zo2=perfective. conn|so2ji5=therefore adv|zau6=then adv:neg|mou5=no +…. gloss: And because the rabbit fell asleep, (it) did not …	Brookshire & Nicholas, 1995; McNeil et al., 2007
Deletion	Obvious deletion of a main verb or a noun	PAR: 首先 將 塊 麵包 焗爐 裡便. %mor: conn|sau2sin1=firstly prep|zoeng1=by_means_of cl|faai3=cl n|min6baau1=bread n|guk6lou4=oven loc|leoi5bin6=inside. gloss: Then, the bread is (put) in the oven. [In this example, the main verb 'put' (擺) was deleted.]	Mayer & Murray, 2003
Comment	A comment made regarding the speaker's knowledge of item	PAR: 因爲 白兔 好 e6 +… 唔 識 講 叫 好 咩. %mor: conn|jan1wai6=because n|baak6to3=rabbit adv|hou2=very fil|e6 +… adv:neg|m4=not v|sik1=know v|gong2=say v|giu3=call adj|hou2=good sfp|me1. gloss: Because the rabbit is very … (I) don't know the word after 'very'.	Boyle, 2004, 2014; Brookshire & Nicholas, 1995; Mayer & Murray, 2003; Pashek & Tompkins, 2002; Schmitter-Edgecombe et al., 2000
Indefinite word	Words that are vague and non-specific	PAR: 有 兩 樣 嘢 賽跑. %mor: v|jau5=have num|loeng5=two cl|joeng6=cl n|je5=thing n|coi3paau2=race. gloss: There are two things having a race. [In this example, the target word 'animal' (動物) was substituted by 'thing'(嘢).]	Boyle, 2004, 2014; Brookshire & Nicholas, 1995; Mayer & Murray, 2003; Schmitter-Edgecombe et al., 2000
Overuse of pronoun/ pronoun without antecedent	Use of pronouns which the referent is ambiguous	PAR: 佢 唔 信 佢 講. %mor: pro|keoi5=he adv:neg|m4=not v|seon3=believe pro|keoi5=he v|gong2=say. gloss: He does not believe what he says.	Mayer & Murray, 2003

Sign	Definition	Example		Sources
Circumlocution	Use of word or phrases to describe certain features or functions of the target noun or verb	PAR:	擺落去一個煎得啱位嘅4地方.	Pashek & Tompkins, 2002
		%mor:	v|baai2=put v:dirc|+v|lok6+v|heoi3=go_down num|jat1=one cl|go3 v|zin1=shallow_fry stprt|dak1 adj|aam1=correct n|wai6=position stprt|ge3 n|dei6fong1=place.	
		gloss:	Put (it) down to a correct position for frying.	

Note: Abbreviation of the symbols in the PAR line: [: text] replacement; & phonological fragment; [/] repetition; (..) long pause; +… trailing off. Abbreviation of the part-of-speech in the %mor line: adj adjective; adv adver; adv:neg adverb: negation; asp aspect marker; aux auxiliary verb; cl classifier; conn connective; dem demonstrative; fil filler; loc locative; n noun; num numeral; poss possessive; prep preposition; pro pronoun; sfp sentence-final particle; stprt sentence particle; v verb; v:dirc v: direction (see details in MacWhinney, 2000).

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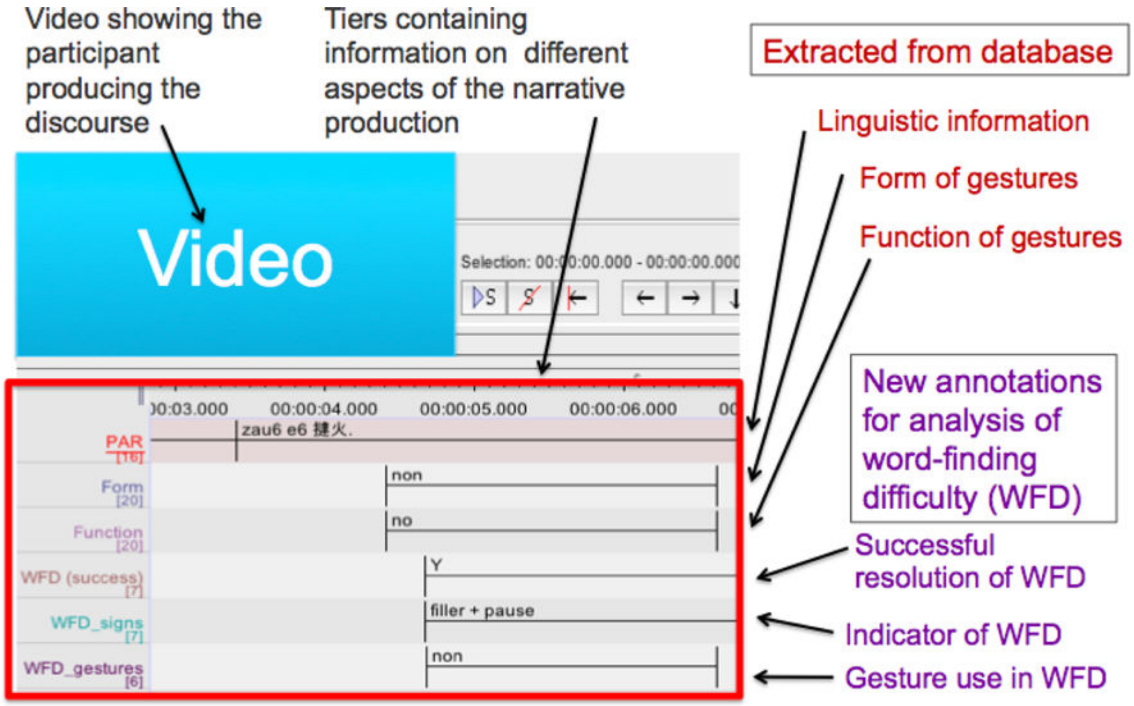

Figure 1.
Independent tiers in ELAN file

Table 1

Inter-rater and Intra-rater Reliability of Indicator and Gesture Forms of WFD and Success of Word Retrieval

		Kendall's tau coefficient[1]		Point-to-point agreement	
		Inter-rater	Intra-rater	Inter-rater	Intra-rater
Indicators of WFD[2]				75.3% (125/166)	88.3% (158/179)
	Verbal paraphasia	.45**	.92***		
	Phonemic paraphasia	.50**	.75***		
	Neologism/Jargon	.80***	1.00***		
	False-start	.69***	.91***		
	Revision	.76***	.84***		
	Repetition	.69***	.88***		
	Pause	.80***	1.00***		
	Filler	.60***	.90***		
	Abandoned sentence	.71***	.79***		
	Deletion	.54**	.70***		
	Comment	1.00***	1.00***		
	Indefinite word	1.00***	1.00***		
Gesture (forms)				92.2% (153/166)	97.2% (174/179)
	Iconic	.99***	.99***		
	Metaphoric	.81***	.99***		
	Deictic	.99***	1.00***		
	Emblem	1.00***	1.00***		
	Beat	.81***	.81***		
	Non-identifiable	.98***	1.00***		
Success of word retrieval				91.6% (152/166)	98.9% (177/179)
	Successful	.76***	.92***		
	Unsuccessful	.59***	.85***		

	Kendall's tau coefficient[1]		Point-to-point agreement	
	Inter-rater	**Intra-rater**	**Inter-rater**	**Intra-rater**
Total number of WFD	.79***	.89***		
Identification of WFD			70.0% (166/237)	91.8% (179/195)

Note 1.

** $p < .01$,

*** $p < .001$.

Using Cohen's standard to evaluate the strength of relationships, coefficients of 0.10-0.29, 0.30-0.49, and 0.50-1.00 represent a small, moderate, and large association, respectively (Reimann, Filzmoser, Garrett, & Dutter, 2008).

Note 2. The signs "overuse of pronoun/pronoun without antecedents" and "circumlocution" are not included because they did not appear in the reliability samples.

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Table 2

Percentage Distribution of WFD Indicators

Indicators	Speaker Groups	
	Controls (total WFD Indicators = 1,162)	PWAs (total WFD Indicators = 1,779)
Verbal paraphasia	5.68	6.75
Phonemic paraphasia	3.79	6.07
Neologism/Jargon	0.52	0.90
False-start	35.46	24.17
Revision	27.62	14.45
Repetition	15.75	21.02
Pause	0.69	6.63
Filler	2.15	7.76
Abandoned sentence	5.08	6.35
Deletion	1.46	0.90
Comment	0.69	1.80
Indefinite word	1.03	2.64
Overuse of pronoun/Pronoun without antecedents	0.09	0.45
Circumlocution	0.00	0.11

Table 3

Percentage Distribution of Forms of Gestures (Used after WFD) and the WFD Indicators

	Gesture Forms												% of Indicators	
	Content-carrying gestures								Non-content carrying gestures					
	Iconic		Metaphoric		Deictic		Emblem		Beat		Non			
	Cont	PWA	Cont	PWA	Cont	PWA	Cont	PWA	Cont	PWA	Cont	PWA	Cont	PWA
% of gesture forms	9.9	6.3	4.2	6.6	16.9	16.7	0.0	1.2	1.4	7.3	67.6	61.9		
Indicators (%)														
Verbal paraphasia	0.0	0.7	2.8	0.5	2.8	1.2	0.0	0.2	0.0	0.7	7.0	0.7	12.7	4.1
Phonemic paraphasia	1.4	0.2	0.0	0.5	1.4	0.5	0.0	0.0	0.0	1.2	1.4	3.6	4.2	6.1
Neologism/Jargon	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.7	0.0	1.0
False-start	2.8	1.9	0.0	1.2	2.8	4.1	0.0	0.2	0.0	1.5	15.5	15.5	21.1	24.5
Revision	1.4	0.2	1.4	0.5	7.0	1.9	0.0	0.0	1.4	0.5	16.9	9.7	28.2	12.9
Repetition	4.2	2.2	0.0	2.4	2.8	5.3	0.0	0.7	0.0	2.4	11.3	15.0	18.3	28.2
Pause	0.0	0.2	0.0	0.7	0.0	0.2	0.0	0.0	0.0	0.2	1.4	3.9	1.4	5.3
Filler	0.0	0.5	0.0	0.7	0.0	1.9	0.0	0.0	0.0	0.0	7.0	7.8	7.0	10.9
Abandoned sentence	0.0	0.2	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	5.6	3.4	5.6	4.6
Deletion	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	1.4	0.5	1.4	1.0
Comment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indefinite word	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.7	0.0	1.2
Overuse of pronoun/Ppronoun without antecedents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
Circumlocution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note. The percentage is based on WFD Indicators followed by employment of one or more gestures. There was a total number of 71 gestures in controls and 412 gestures in PWA. Cont = control speakers; PWA = persons with aphasia.

Table 4

Distribution of Different Gesture Forms during WFD

	All incidents of WFD (i.e., resolved and unresolved WFD)		Incidents of WFD with successful retrieval of targets (i.e., resolved WFD)	
	Controls	**PWAs**	**Controls**	**PWAs**
Number of Gestures	100	868	78	543
Gesture forms				
Iconic	7.00%	4.72%	7.69%	5.52%
Metaphoric	3.00%	5.88%	1.28%	6.26%
Deictic	21.00%	14.98%	21.79%	15.84%
Emblem	0.00%	0.58%	0.00%	0.74%
Beat	2.00%	7.03%	2.56%	7.00%
Non-identifiable	67.00%	66.82%	66.67%	64.64%

Table 5

Descriptive Statistics of the Predicted and Predictor Variables

	Predicted Variable	Predictor Variables								
	Success rate of word retrieval	**CAB AQ**	**SWPM**	**WWPM**	**SAT**	**SJT**	**PPTT**	**Object naming**	**Action naming**	**Ratio of content-carrying to non-content carrying gestures**
Mean	64.25%	88.73	120.40	120.81	52.09	49.67	25.43	84.29	70.32	0.76
SD	18.77%	7.33	5.60	6.50	4.90	5.44	6.25	10.71	17.32	1.94
Min.	0.00%	66.90	99.00	80.00	34.00	33.00	9.00	55.00	24.00	0.00
Max.	100.00%	99.00	126.00	126.00	58.00	58.00	67.00	100.00	100.00	12.00

Note. CAB AQ = Aphasia Quotient of Cantonese Aphasia Battery; SWPM = Spoken Word-Picture Matching; WWPM = Written Word-Picture Matching; SAT = Semantic Access Test in Birmingham Object Recognition Battery; SJT = Synonym Judgment Test; PPTT = Pyramid and Palm Tree Test.

Table 6

Correlation Coefficients of Predicted and Predictor Variables

	CAB AQ	SWPM	WWPM	SAT	SJT	PPTT	Object naming	Action naming	Ratio of content-carrying to non-content carrying gestures
Success rate	.370**	.353**	.073	.186	.009	.244	.515***	.482***	.195
CAB AQ		.366**	.233	.299*	.310*	.186	.530***	.637***	−.097
SWPM			.322*	.515***	.242	.286*	.528***	.457***	.029
WWPM				.598***	.315*	.275*	.295*	.383**	−.027
SAT					.275*	.367**	.420***	.421***	−.062
SJT						.204	.485***	.338*	−.244
PPTT							.290*	.275*	.021
Object naming								.695***	−.087
Action naming									−.073

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

CAB AQ = Aphasia Quotient of Cantonese Aphasia Battery; SWPM = Spoken Word-Picture Matching; WWPM = Written Word-Picture Matching; SAT = Semantic Access Test in Birmingham Object Recognition Battery; SJT = Synonym Judgment Test; PPTT = Pyramid and Palm Tree Test.

Table 7

Results of Multiple Regression Analyses

Predictor	***B***	***SE B***	***β***	***t***	***p***
Step 1					
Constant	−.155	.183		−.848	.402
Object naming	.010	.002	.599	4.430	.000
Step 2					
Constant	−.623	.264		−2.354	.024
Object naming	.006	.002	.403	2.636	.013
CAB AQ	.008	.004	.356	2.329	.026

Note. R^2 = .359 for Step 1 ($p < .001$); ΔR^2 = .088 for Step 2 ($p < .001$).